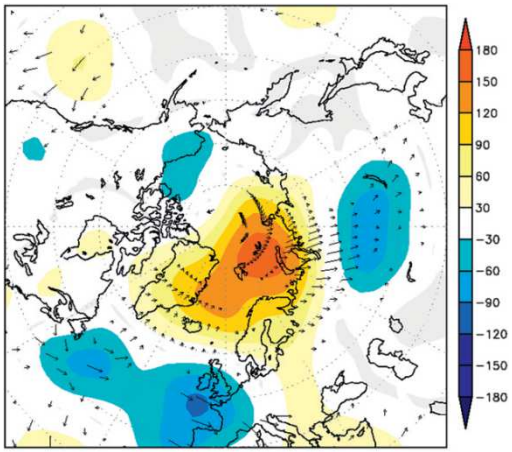
On polar-nonpolar linkages: observations and model diversity (eastern Arctic sea-ice variability)

J. García-Serrano (LOCEAN/IPSL, **BSC**), C. Frankignoul (LOCEAN/IPSL)

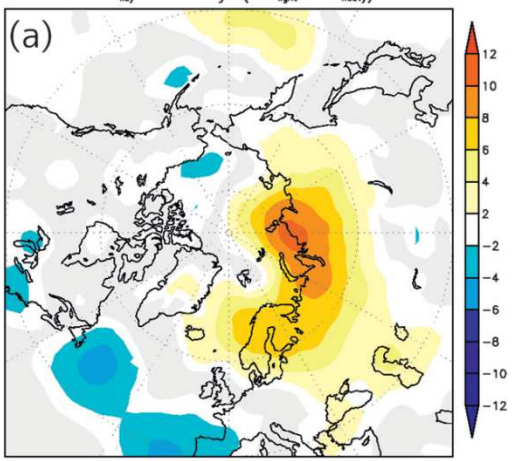
with contributions/feedback: [OBS] G. Gastineau (LOCEAN/IPSL), A. de la Cámara (LMD/IPSL, NCAR) [MOD] A. Arribas (MetOffice), Y. Gao (NERSC/BCCR), V. Guemas (BSC, CNRM), M. P. King (URC/BCCR), D. Matei (MPI-M), R. Msadek (GFDL, CERFACS), W. Park (GEOMAR), E. Sanchez-Gomez (CERFACS)

InterDec kick-off meeting

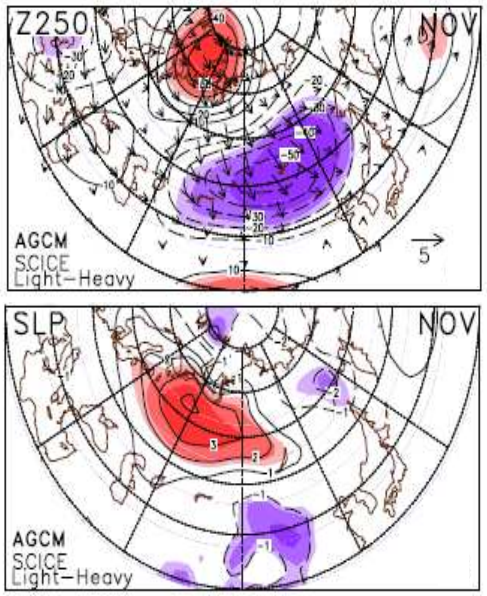
Z250 / WAF (DJF)



SLP$_{key}$ anomaly (Ice$_{light}$−Ice$_{heavy}$)



Inoue et al. (2012, GRL)

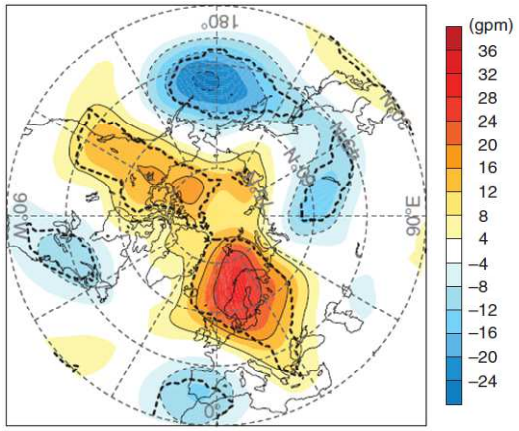


Honda et al. (2009, GRL)

might be non-linear to SIC reduction!

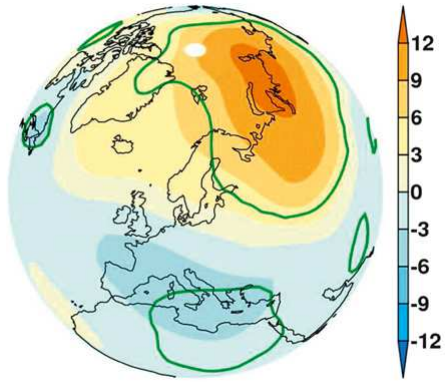
Petoukhov and Semenov (2010, JGR)

ΔZ500 for ND, CAM5



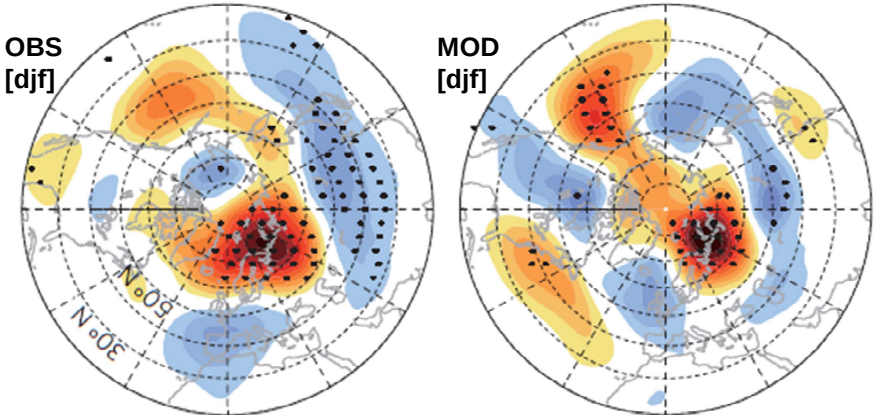
Kim et al. (2014, Nat.Comms)

SLP JAN [CAM]

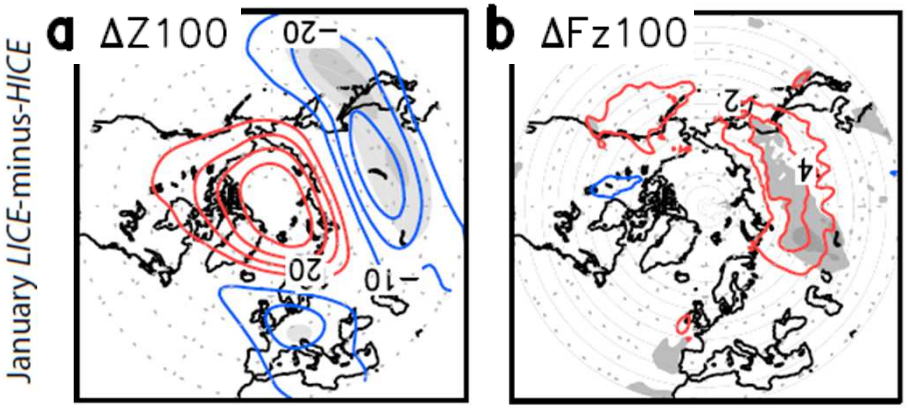


Grassi et al. (2013, JCLIM)

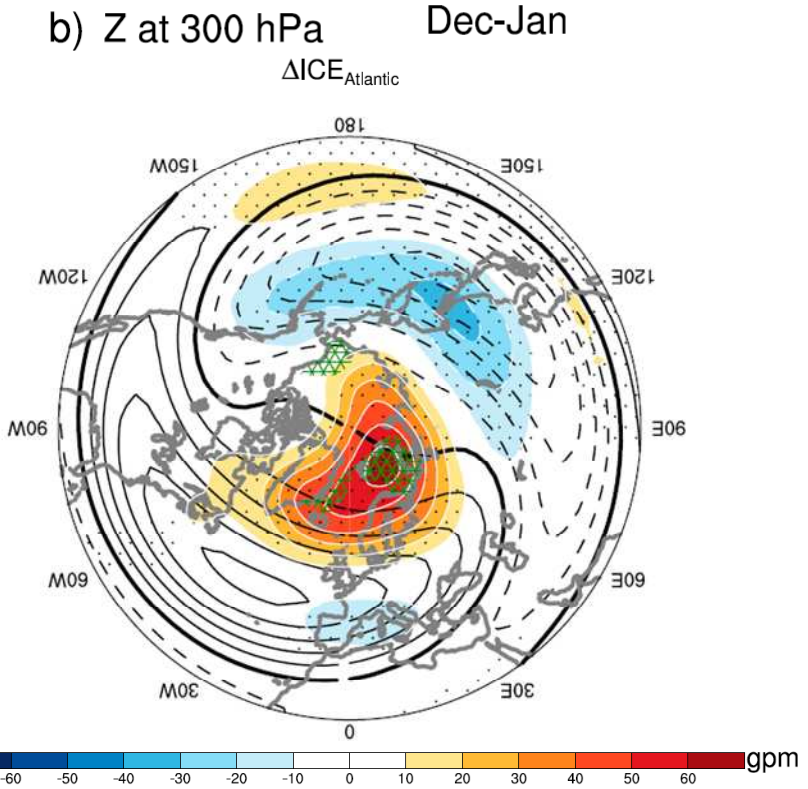
RECENT REVIEWS: Bader et al. 2011; Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015



Mori et al. (2014, Nat.Geosci)



Nakamura et al. (2016, GRL)



Sun et al. (2015, JCLIM)

might be non-linear to SIC reduction!

Petoukhov and Semenov (2010, JGR)

RECENT REVIEWS: Bader et al. 2011; Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015

García-Serrano et al. (2015, JCLIM); similar to Nakamura et al. (2015, JGR); King et al. (2016, ClimDyn)

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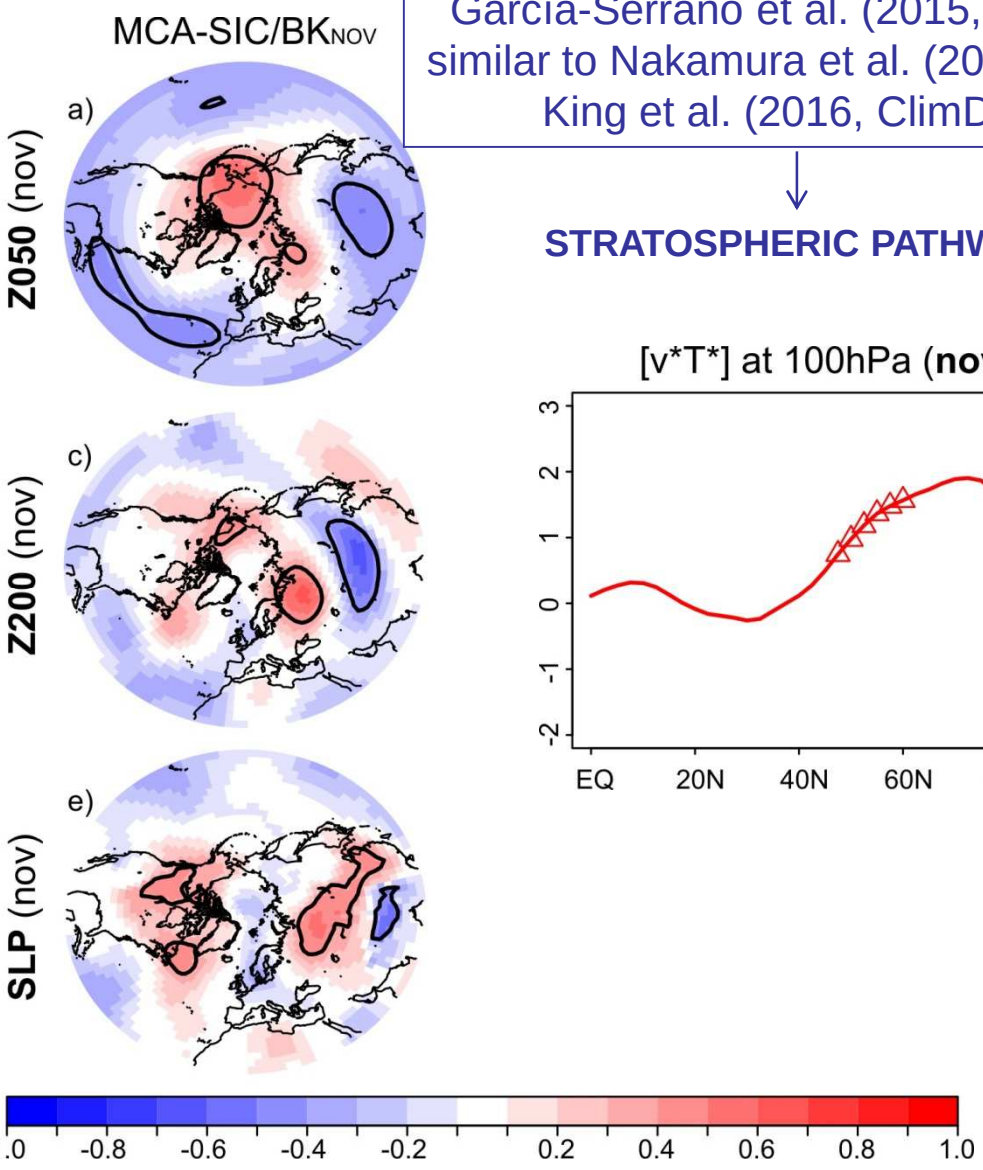
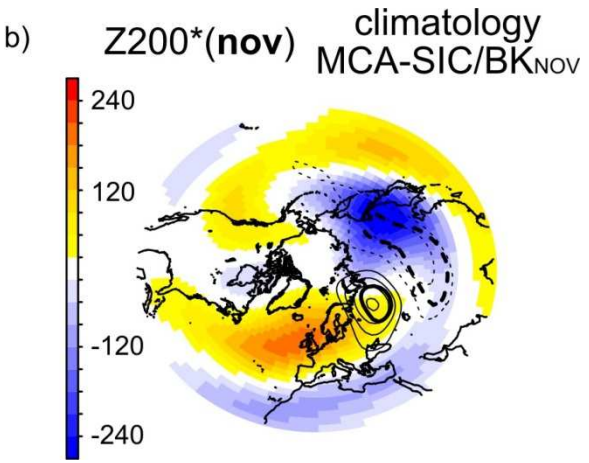
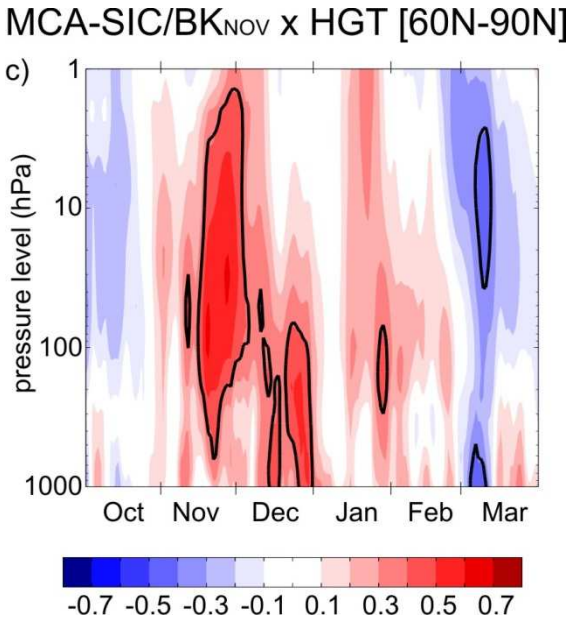
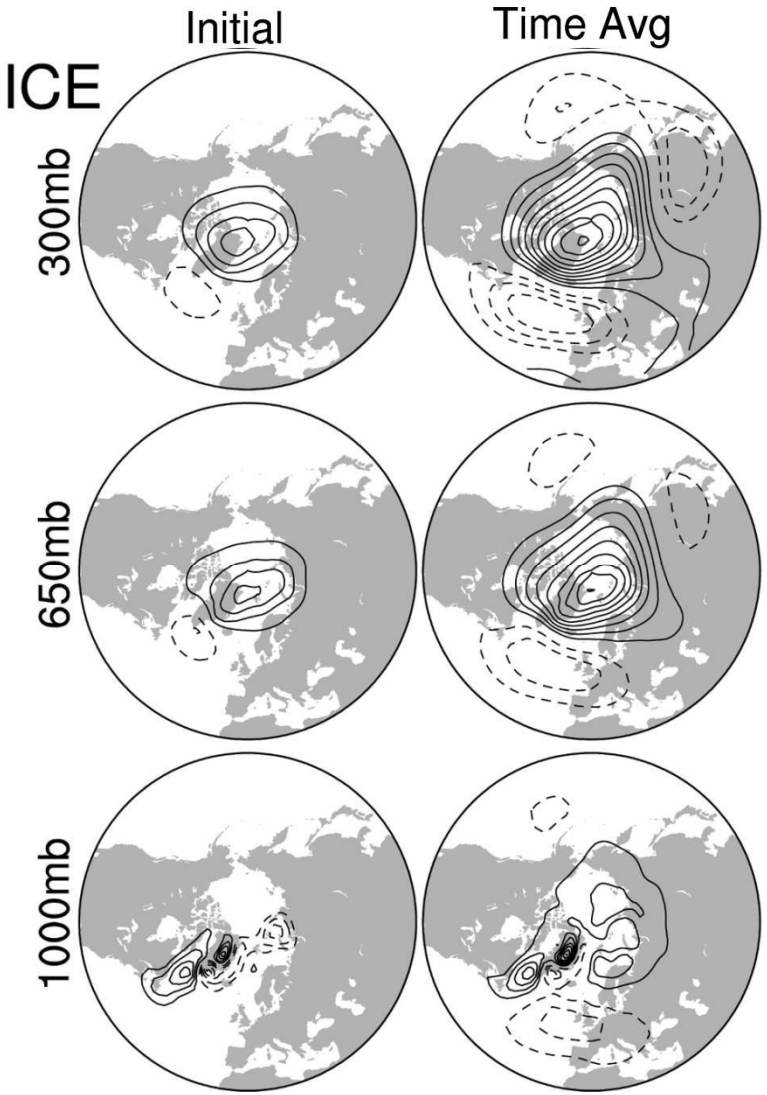
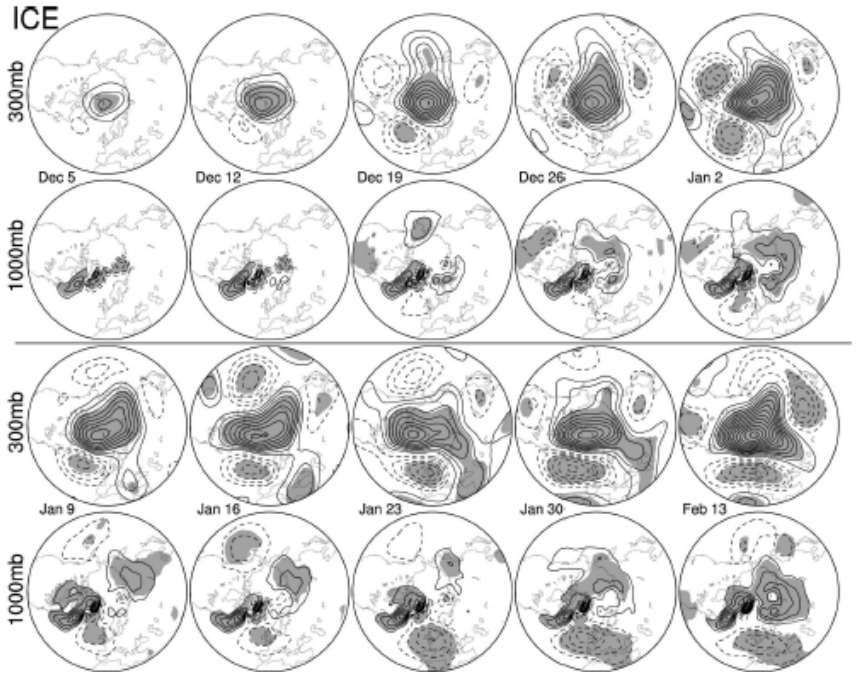
STRATOSPHERIC PATHWAY





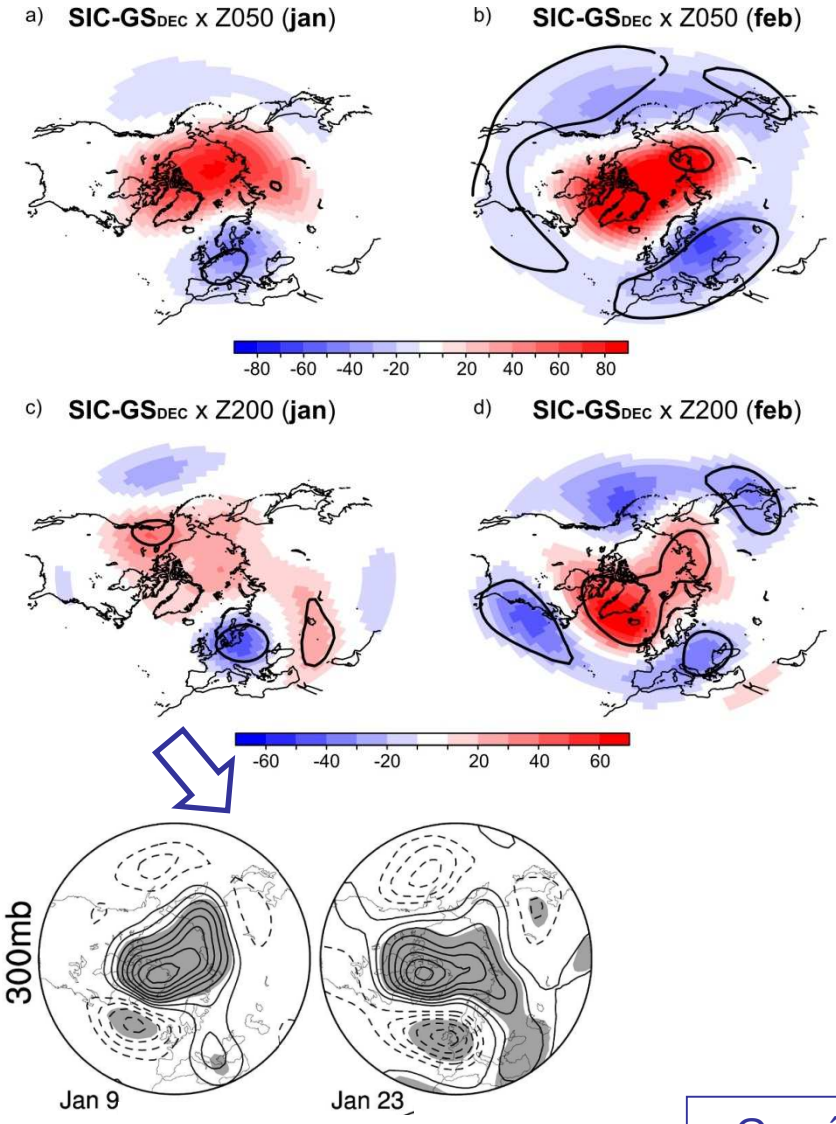




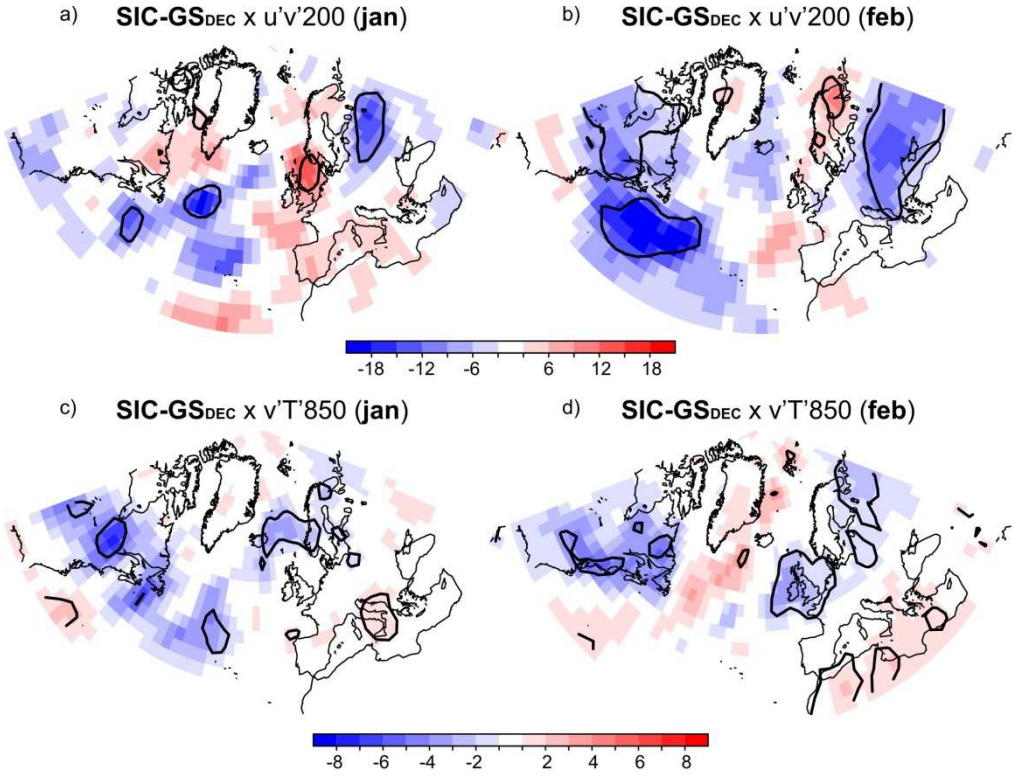


the equilibrium response to SIC reduction over G-B Seas, which projects on the negative NAO, is reached in about two months

Deser et al. (2007, JCLIM)



Deser et al. (2007, JCLIM)



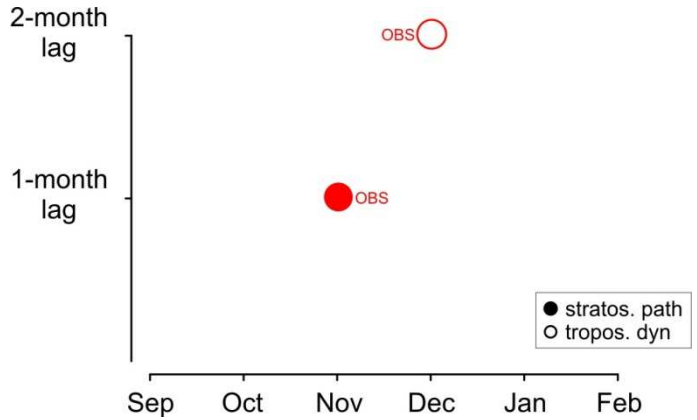
TROPOSPHERIC DYNAMICS

García-Serrano and Frankignoul (2015, ClimDyn)

- Maximum Covariance Analysis (MCA) applied to SIC over the eastern Arctic (GBK Seas) and SLP over the NAE region; NSIDC, HadISST, ERA-interim yield identical results

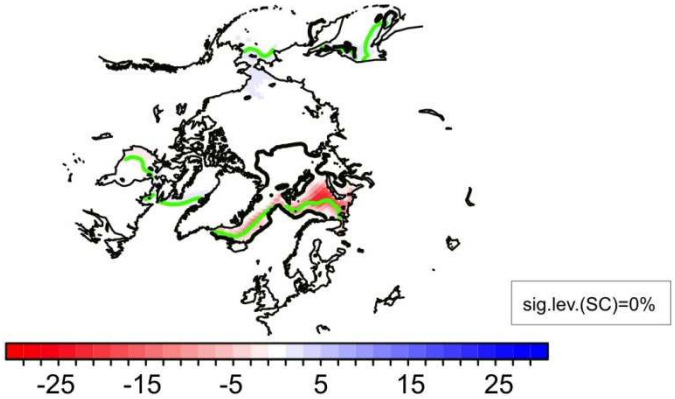
- detrended, monthly anomalies; period 1979-2013; target – cold season (September-to-February)

- **CMIP5**: no multi-model, each model individually; CCSM4 (5mb), CNRM-CM5 (10mb), EC-EARTH2.3 (3mb), GFDL-CM2.1 (10mb), HadGEM2-ES (4mb), IPSL-CM5A-LR (3mb), MPI-ESM-MR (3mb), NorESM1-M (3mb) - HISTORICAL+RCP4.5 RUNS

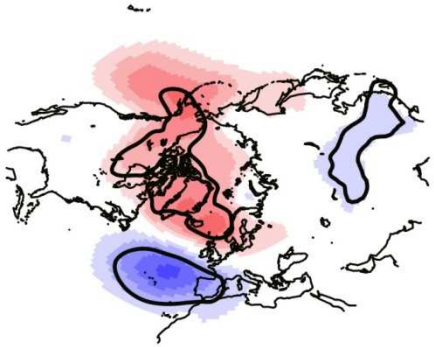


CNRM

a) **MCA-SIC/eA$_{DEC}$** x SIC (**dec**)

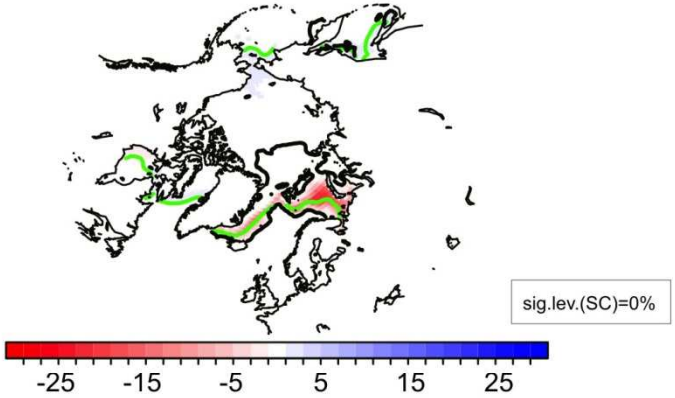


b) **MCA-SIC/eA$_{DEC}$** x SLP (**jan**)

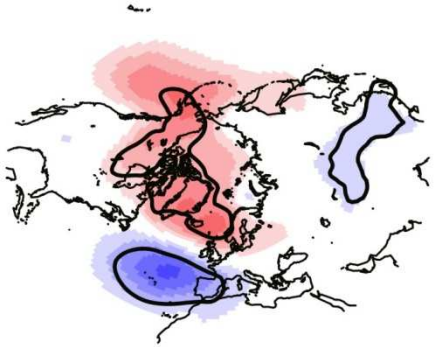


CNRM

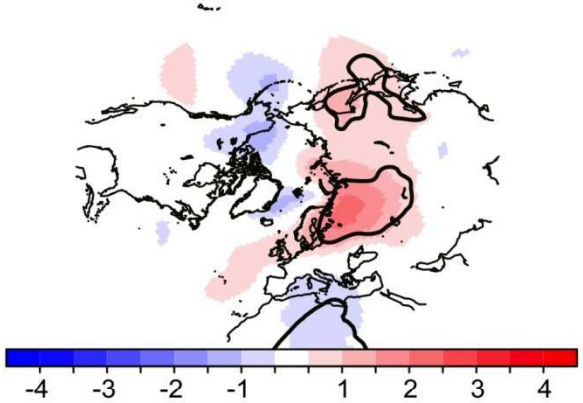
a) **MCA-SIC/eA$_{DEC}$** x SIC (**dec**)



b) **MCA-SIC/eA$_{DEC}$** x SLP (**jan**)

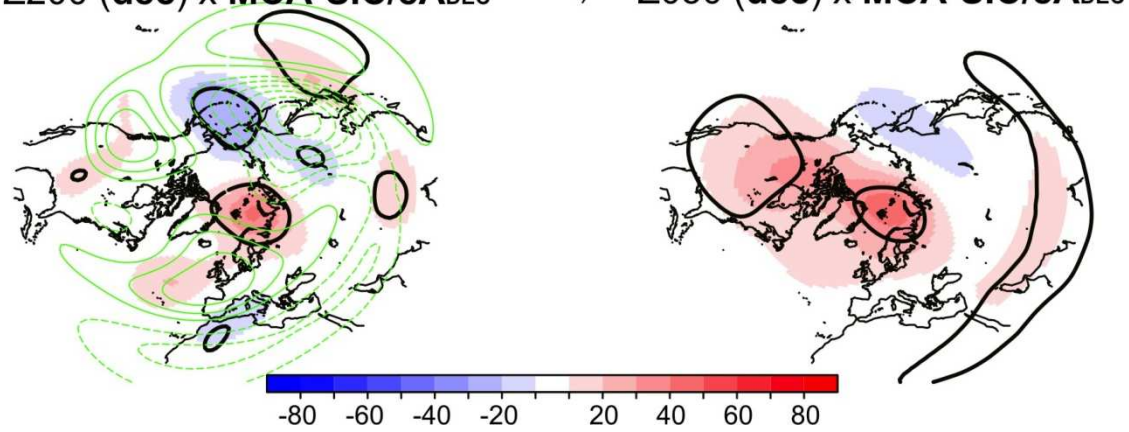


c) SLP (**dec**) x **MCA-SIC/eA$_{DEC}$**



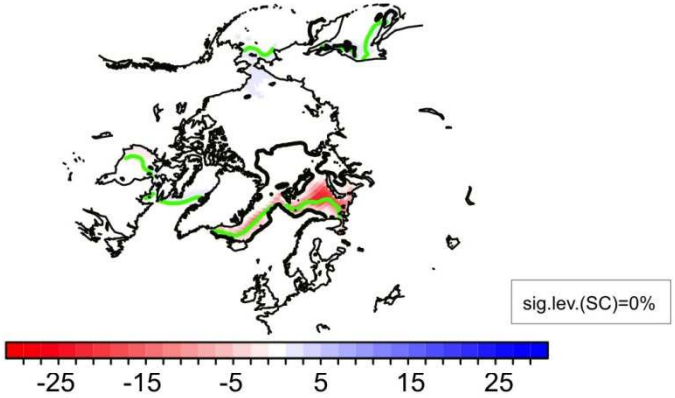
e) Z200 (**dec**) x **MCA-SIC/eA$_{DEC}$**

f) Z050 (**dec**) x **MCA-SIC/eA$_{DEC}$**

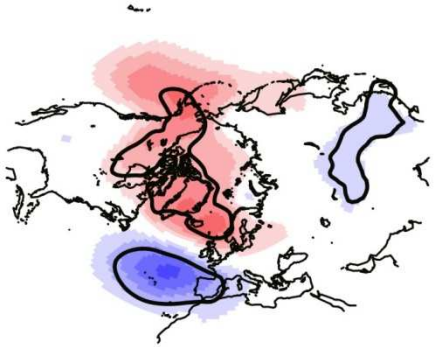


CNRM

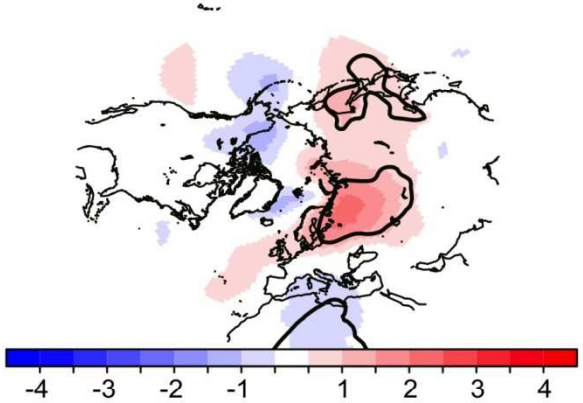
a) **MCA-SIC/eA$_{DEC}$** x SIC (**dec**)



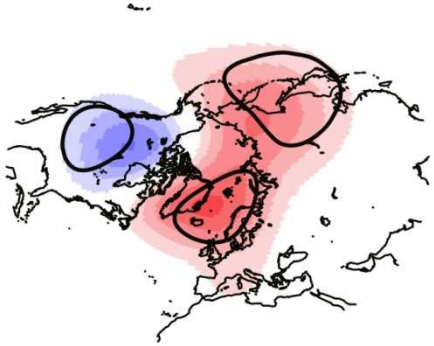
b) **MCA-SIC/eA$_{DEC}$** x SLP (**jan**)



c) SLP (**dec**) x **MCA-SIC/eA$_{DEC}$**



d) Z050 (**jan**) x **MCA-SIC/eA$_{DEC}$**



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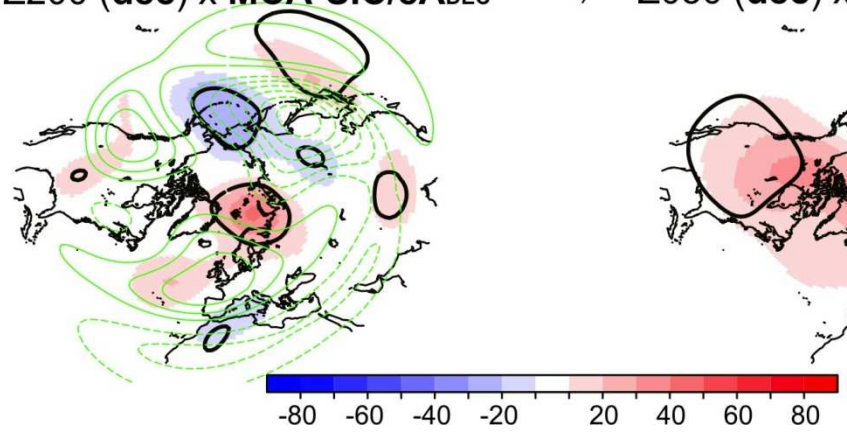
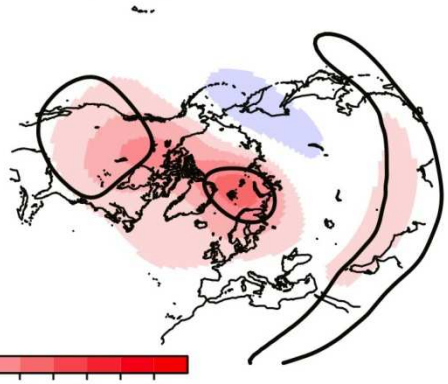
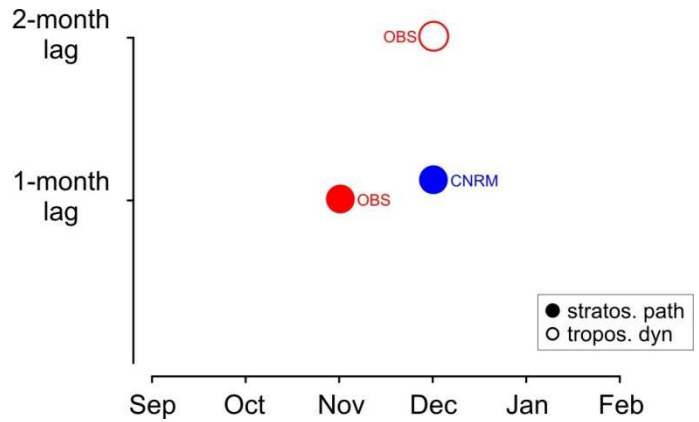


f) Z050 (**dec**) x **MCA-SIC/eA$_{DEC}$**




2-month lag
1-month lag
OBS
CNRM
OBS
stratos. path
tropos. dyn
Sep
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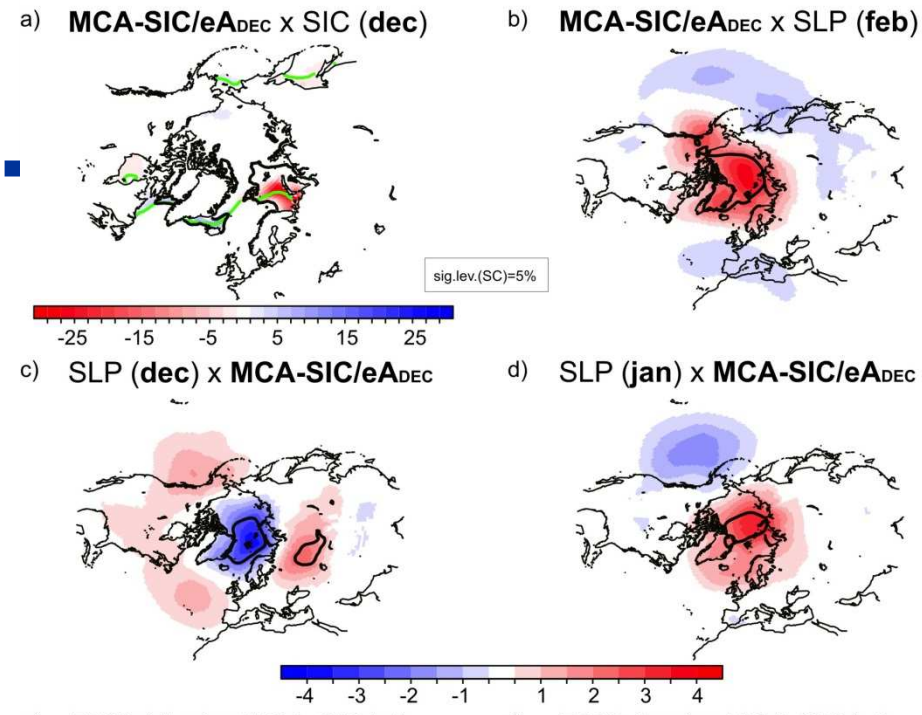
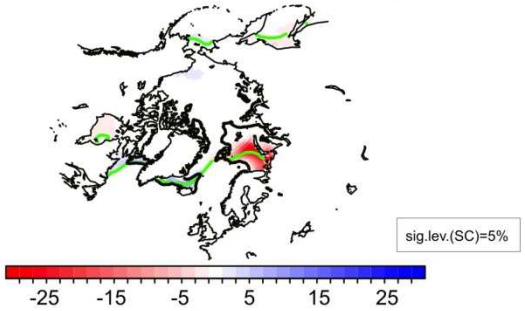
Nov
Dec
Jan
Feb

CCSM

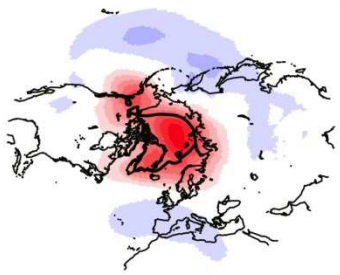

a) MCA-SIC/eA$_{DEC}$ x SIC (dec)
b) MCA-SIC/eA$_{DEC}$ x SLP (feb)
sig.lev.(SC)=5%
-25 -15 -5 5 15 25
c) SLP (dec) x MCA-SIC/eA$_{DEC}$
d) SLP (jan) x MCA-SIC/eA$_{DEC}$
-4 -3 -2 -1 1 2 3 4

CCSM

a) **MCA-SIC/eA$_{DEC}$** x SIC (**dec**)

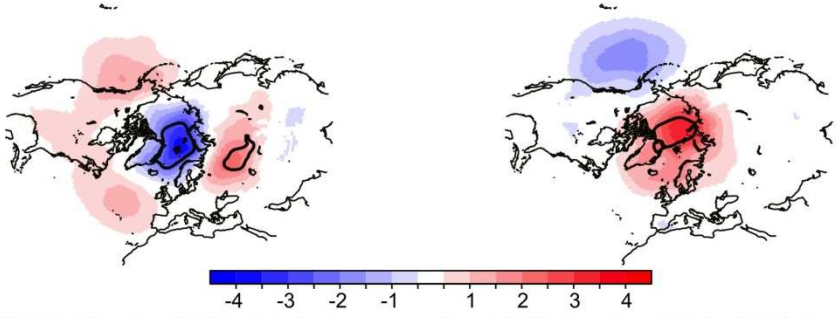


b) **MCA-SIC/eA$_{DEC}$** x SLP (**feb**)

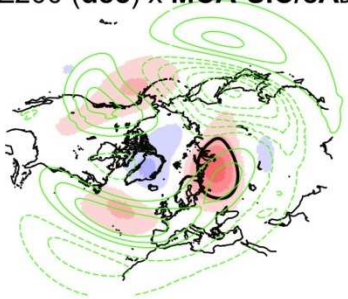


c) SLP (**dec**) x **MCA-SIC/eA$_{DEC}$**

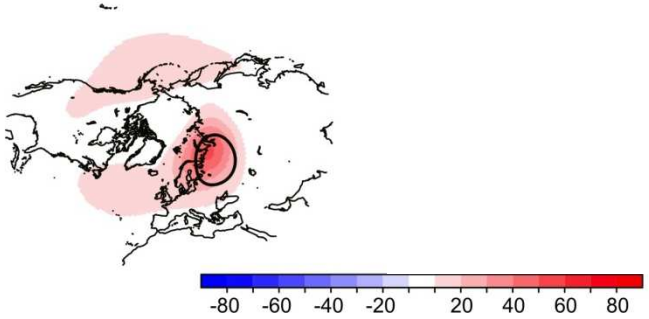
d) SLP (**jan**) x **MCA-SIC/eA$_{DEC}$**

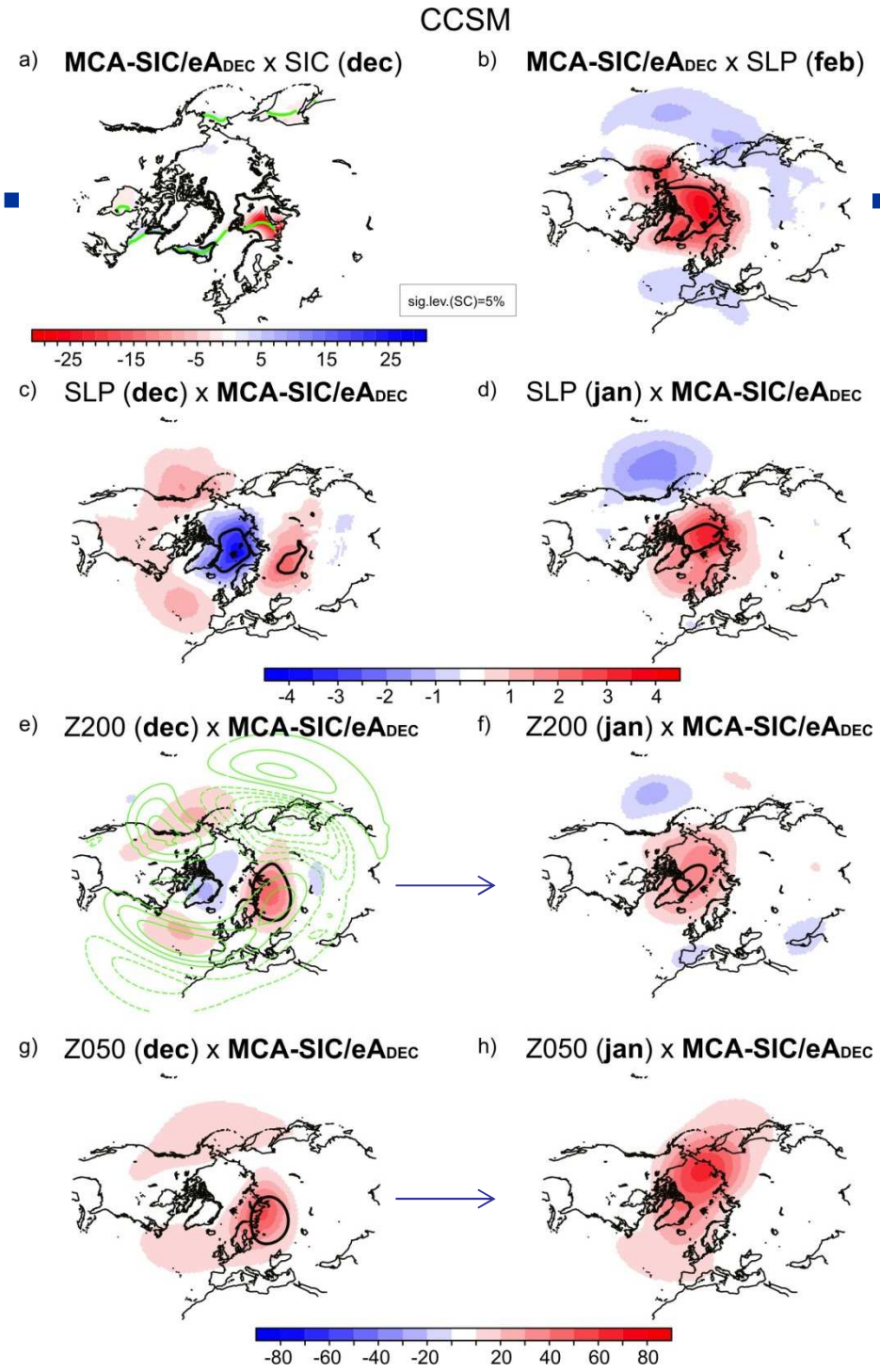


e) Z200 (**dec**) x **MCA-SIC/eA$_{DEC}$**



g) Z050 (**dec**) x **MCA-SIC/eA$_{DEC}$**




CCSM
a) MCA-SIC/eA$_{DEC}$ x SIC (dec)
b) MCA-SIC/eA$_{DEC}$ x SLP (feb)
sig.lev.(SC)=5%
-25 -15 -5 5 15 25
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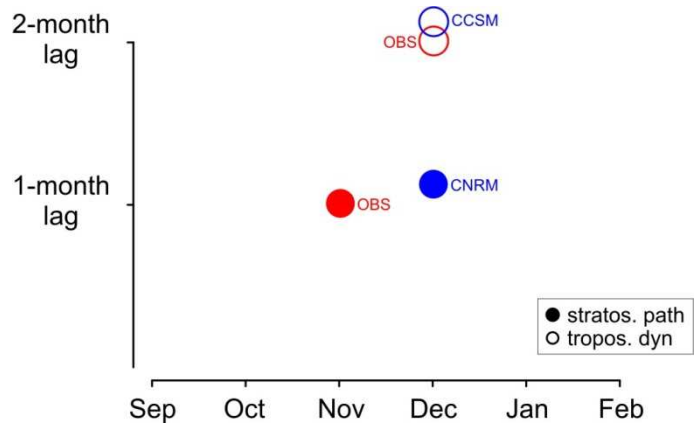
-4 -3 -2 -1 1 2 3 4
e) Z200 (dec) x MCA-SIC/eA$_{DEC}$
f) Z200 (jan) x MCA-SIC/eA$_{DEC}$
g) Z050 (dec) x MCA-SIC/eA$_{DEC}$
h) Z050 (jan) x MCA-SIC/eA$_{DEC}$
-80 -60 -40 -20 20 40 60 80


2-month lag
1-month lag
CCSM
OBS
CNRM
OBS
stratos. path
tropos. dyn
Sep
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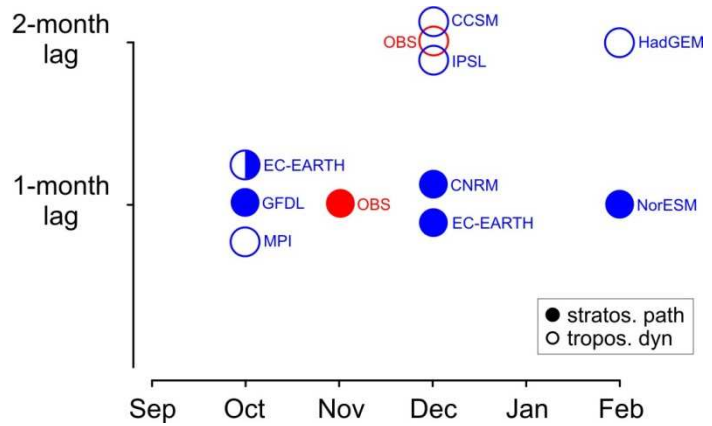
2-month lag
1-month lag
CCSM
OBS
IPSL
HadGEM
EC-EARTH
GFDL
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MPI
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Sep
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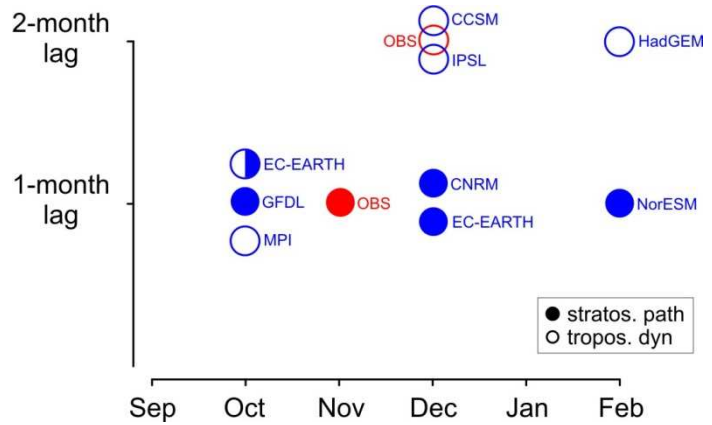
SUMMARY

- CMIP5 models analysed here show a significant link with sea-ice reduction over the eastern Arctic (Greenland-Barents-Kara Seas) followed by a negative NAO-like pattern

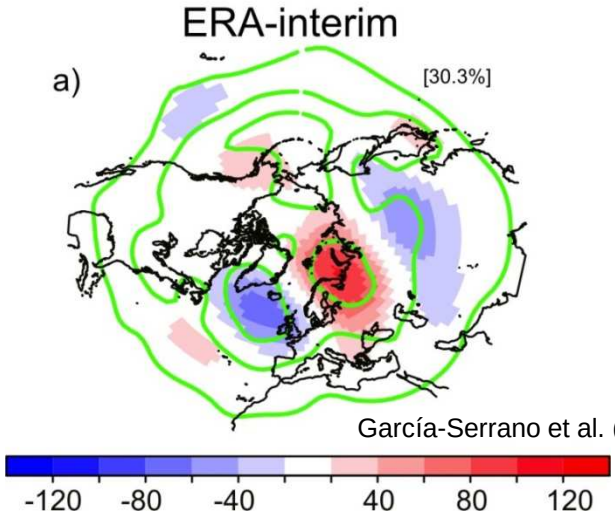
- The timing of the simulated relationships is strongly model dependent, which suggests that the atmospheric sensitivity to sea-ice changes depends on the simulated mean-flow (internal variability) → source of uncertainty in climate prediction and projection

- Target experiments are needed to gain insight into the role played by the background-flow; to be assessed in *PRIMAVERA* (H2020/SC5) and *APPLICATE* (H2020/BG10)



García-Serrano et al. (2016, ClimDyn)

EOF1 Z200-Eurasia (**nov**)

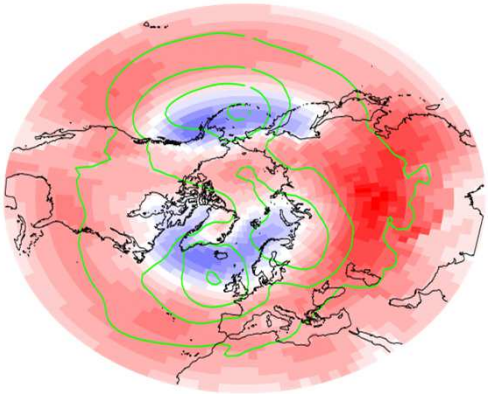


García-Serrano et al. (2016, ClimDyn)

the **Ural-Siberian** anticyclone

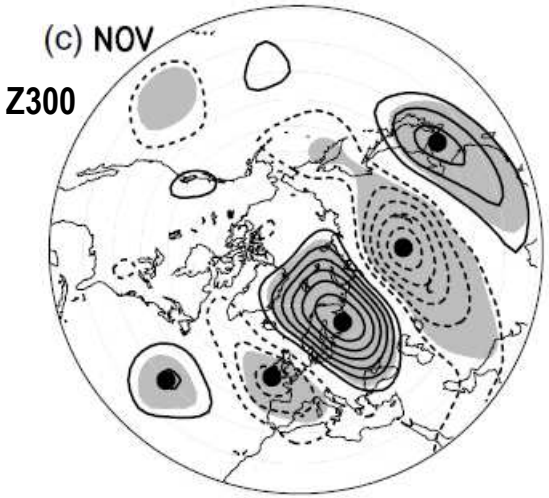
Santolaria et al.
(in preparation)

SLP (Nov) clim. + std.dev.



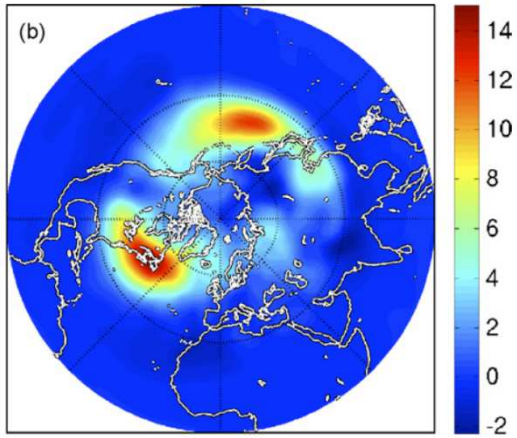
Santolaria et al. (in preparation)

the **SCA** pattern



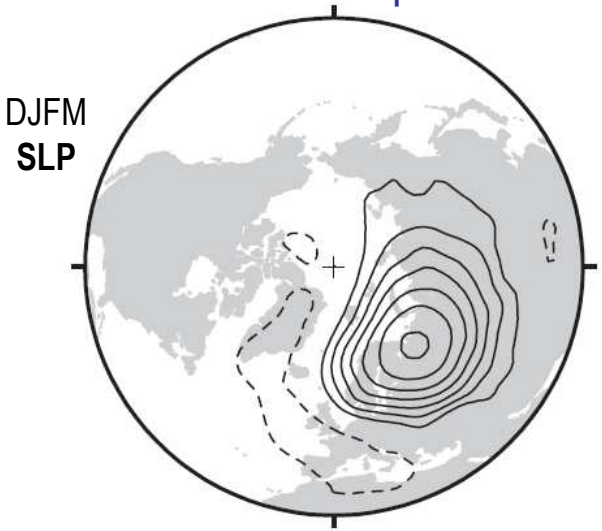
Bueh and Nakamura (2007, QJRMS)

v'T' 500hPa (DJF)



Vallis and Gerber (2008, DynAO)

the **Russian** pattern



Smoliak and Wallace (2015, JAS)

EXTRA SLIDES

The research leading to these results has received funding from the European Union 7th Framework Programme (FP7 2007-2013), under grant agreement n.308299 (NACLIM – www.naclim.eu)

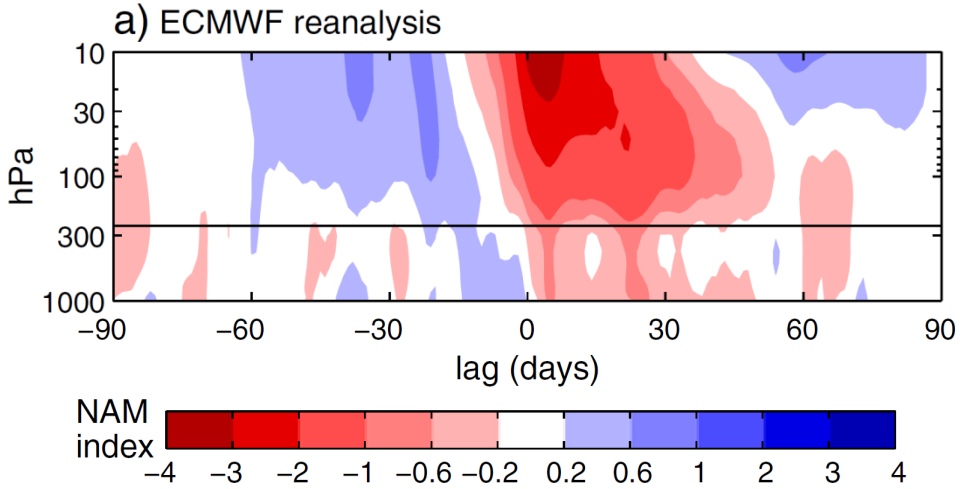
García-Serrano et al. (2015, JCLIM); similar to Nakamura et al. (2015, JGR); King et al. (2016, ClimDyn)

↓

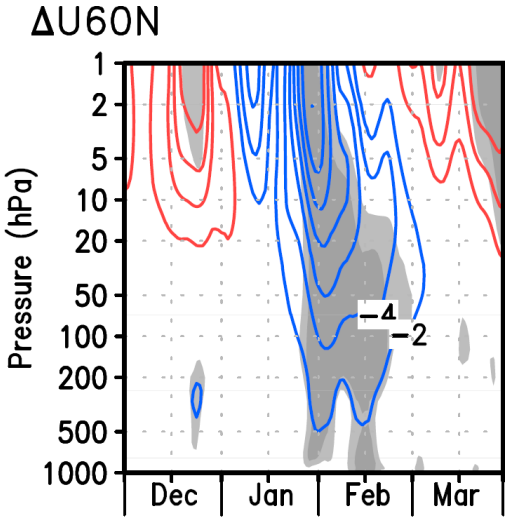
STRATOSPHERIC PATHWAY

troposphere-stratosphere coupling between (heat-flux) eddy waves and climatological wave pattern is instantaneous

Shaw et al. (2014, JGR)

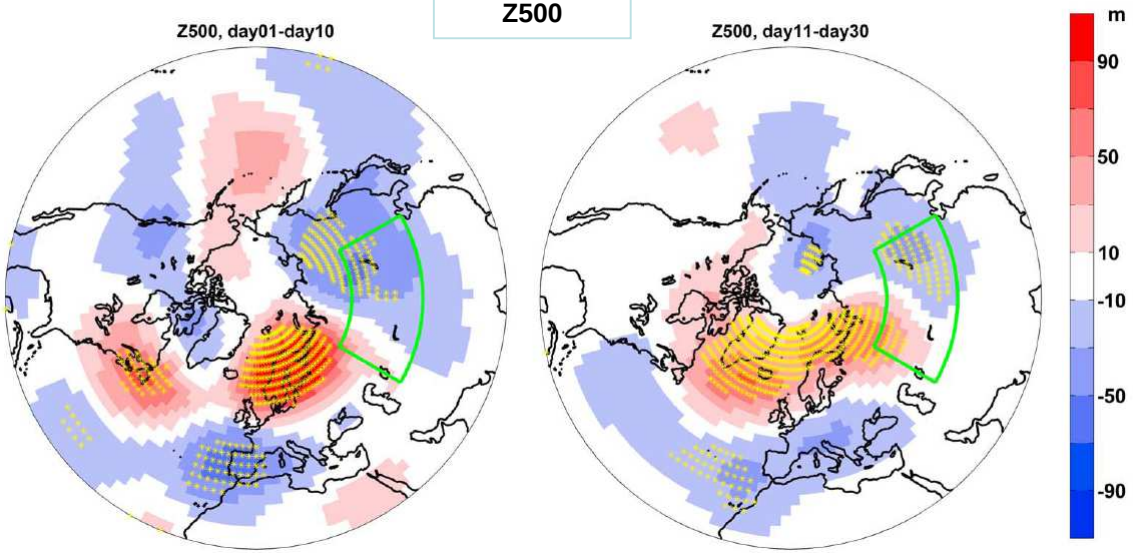


Charlton-Perez et al. (2013, JGR)



Nakamura et al. (2016, GRL)

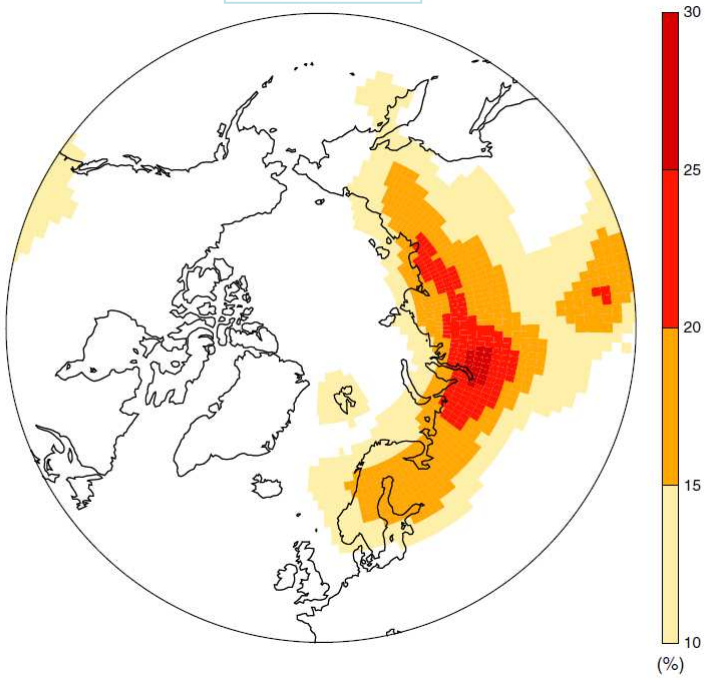
Z500



Jung et al. (2014, GRL)

initializing sea-ice reduces RMSE over Eurasia

SLP



Day et al. (2014, GRL)

RECENT REVIEWS: Bader et al. 2011; Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015